## Claims

- [c1] 1. A catalyst system for use in reducing emissions from an exhaust gas stream containing hydrocarbons, CO and NOx comprising:
  - a first catalyst for optimizing the storage of NOx emissions under lean air/fuel ratios, comprising a first zone and a second zone;

said first zone comprising a) a catalyst mixture PM-Rh, where PM is a catalyst material selected from the group consisting of Pt, Pd and combinations thereof, and b) a metal oxide selected from the group consisting of oxides of aluminum, alkali metals, alkaline-earth metals, and combinations thereof, wherein said first zone is devoid of cerium;

said second zone comprising a) a catalyst mixture PM-Rh, where PM is a catalyst material selected from the group consisting of Pt, Pd and combinations thereof, and b) a metal oxide selected from the group consisting of alkali metals, alkaline earth metals, rare earth metals and combinations thereof; and a second catalyst for optimizing the reduction of hydrocarbon, NOx and CO emissions under stoichiometric air/fuel ratios comprising: a) a catalyst mixture PM-Rh, where PM is a catalyst material selected from the group consisting of Pt, Pd and combinations thereof, b) a metal oxide selected from the group consisting of oxides of aluminum, alkali metals, alkaline earth metals and combinations thereof, and c) a metal oxide selected from the group consisting of oxides of zirconium, cerium and combinations thereof.

- [c2] 2. The catalyst system of claim 1, wherein said second zone of said first catalyst further comprises zirconium oxide.
- [c3] 3. The catalyst system of claim 1, wherein said second catalyst further comprises hydrogen sulfide emission suppressants.
- [c4] 4. The catalyst system of claim 1, wherein said second catalyst further comprises nickel oxide.
- [c5] 5. The catalyst system of claim 1, wherein said Rh in said first catalyst is placed on  $ZrO_2$  particles of 3-5% (wt).
- [c6]
  6. The catalyst system of claim 1, wherein said catalyst mixtures of said first

and second catalysts are coated on an alumina substrate.

- [c7] 7. The catalyst system of claim 6, wherein said alumina substrate in said first zone is stabilized by between 1-8% (wt) La  $_2$  O  $_3$  .
- [c8] 8. The catalyst system of claim 6, wherein said alumina substrate in said second catalyst is stabilized by 2-15% (wt) BaO.
- [c9] 9. The catalyst system of claim 1, wherein said first zone of said first catalyst further comprises a metal oxide selected from the group consisting of barium oxide, magnesium oxide, potassium oxide and combinations thereof, wherein the metal oxide comprises 2–15% (wt).
- [c10] 10. The catalyst system of claim 1, wherein said second zone of said first catalyst further comprises a metal oxide selected from the group consisting of barium oxide, magnesium oxide and combinations thereof.
- [c11] 11. The catalyst system of claim 10, wherein said second zone of said first catalyst comprises BaO and MgO of 10-40% (wt).
- [c12] 12. The catalyst system of claim 1, wherein said catalyst mixture PM-Rh in said first zone of said first catalyst comprises Pt and Rh in a ratio of between 5:1 and 25:1.
- [c13] 13. The catalyst system of claim 1, wherein said catalyst mixture PM-Rh in said first zone of said first catalyst has a loading of between  $60-300~\mathrm{g/ft}^{-3}$ .
- [c14] 14. The catalyst system of claim 1, wherein said second zone of said first catalyst comprises Pt and Rh in a ratio of between 1:1 and 10:1.
- [c15] 15. The catalyst system of claim 1, wherein said catalyst mixture PM-Rh in said second zone of said first catalyst has a loading of between 10-100 g/ft  $^3$  .
- [c16] 16. The catalyst system of claim 1, wherein said catalyst mixture PM-Rh in said second catalyst comprises Pt and Rh in a ratio of btween 5:1 and 15:1.
- [c17] 17. The catalyst system of claim 1, wherein said catalyst mixture PM-Rh in said second catalyst has a loading of between 10-120 g/ft 3.

- [c18] 18. The catalyst system of claim 1, wherein PM-Rh in said second catalyst comprises Pt and Rh placed on Ce and Zr particles of 5-30% (wt) wherein the molar ratio of Ce and Zr is 50:50.
- [c19] 19. The catalyst system of claim 1, wherein said first catalyst and said second catalyst are close-coupled, said first catalyst being positioned in a forward position and said second catalyst being positioned in a downstream position.
- [c20] 20. The catalyst system of claim 1, wherein an exhaust gas sensor is placed between said first and second catalysts.
- [c21] 21. A catalyst system for use in reducing emissions from an exhaust gas stream containing hydrocarbons, CO and NOx comprising:

  a first catalyst for optimizing the storage of NOx emissions under lean air/fuel ratios comprising a top layer and a bottom layer;
  said top layer comprising a) a catalyst mixture PM-Rh, wherein said PM is a catalyst material selected from the group consisting of Pt and Pd and combinations thereof, and b) a metal oxide selected from the group consisting of oxides of aluminum, alkali metals, alkaline earth metals and combinations thereof, wherein said top layer is devoid of cerium; said bottom layer comprising a) a catalyst mixture comprising PM-Rh wherein PM is a catalyst material selected from the group consisting of Pt, Pd and combinations thereof, and b) a metal oxide selected from the group consisting of oxides of aluminum, alkali metals, alkaline earth metals and combinations thereof; and

a second catalyst for optimizing the reduction of hydrocarbon, NOx and CO emissions under stoichiometric air/fuel ratios comprising a) a catalyst mixture PM-Rh, where PM is a catalyst material selected from the group consisting of Pt, Pd and combinations thereof, and b) a metal oxide selected from the group consisting of oxides of aluminum, alkali metals, alkaline earth metals and combinations thereof, and c) a metal oxide selected from the group consisting of oxides of zirconium, cerium, and combinations thereof.

[c22] 22. The catalyst system of claim 21, wherein said top layer of said first catalyst comprises Pt and Rh in a ratio of between 5:1 and 25:1.

- [c23] 23. The catalyst system of claim 21, wherein said catalyst mixture PM-Rh in said top layer of said first catalyst has a loading of between  $60-300 \text{ g/ft}^3$ .
- [c24] 24. The catalyst system of claim 21, wherein said catalyst mixture PM-Rh in said top layer of said first catalyst comprises Pt-Rh stabilized by 2-15 wt% of BaO.
- [c25] 25. The catalyst system of claim 21, wherein said Rh in said second bottom layer of said first catalyst is placed on ZrO particles of 3-5% (wt) and BaO and MgO particles of 2-30% (wt).
- [c26] 26. The catalyst system of claim 21, wherein said catalyst mixtures of said first and second catalysts are coated on an alumina substrate.
- [c27]. 27. The catalyst system of claim 26, wherein said alumina substrate in said bottom layer of said first catalyst is stabilized by between 2-8% (wt) La  $_2$  O  $_3$ .
- [c28] 28. The catalyst system of claim 26, wherein said alumina substrate in said bottom layer of said first catalyst is stabilized by composite oxides of cerium-lanthanum.
- [c29] 29. The catalyst system of claim 21, wherein said catalyst mixture PM-Rh in said second catalyst comprises Pt and Rh in a ratio of between 5:1 and 15:1 with a total loading of between  $10-120 \text{ g/ft}^3$ .
- [c30] 30. The catalyst system of claim 21, wherein PM-Rh in said second catalyst comprises Pt and Rh placed on Ce and Zr particles of 5-30 wt%, wherein the molar ratio of Ce and Zr is 50:50.
- [c31] 31. A catalyst for use with an internal combustion engine to provide emission reductions, comprising:
  a first and a second zone;
  said first zone comprising a) a catalyst mixture PM-Rh where PM is a catalyst

material selected from the group consisting of Pt, Pd and combinations thereof, and b) a metal oxide selected from the group consisting of cerium, zirconium and combinations thereof; and

said second zone comprising a) a catalyst mixture PM-Rh, where PM is a catalyst material selected from the group consisting of Pt, Pd and combinations thereof;

and b) a metal selected from the group consisting of oxides of aluminum, alkali metals, alkaline earth metals and combinations thereof, wherein said second zone is devoid of cerium.

[c32] 32. A catalyst for use with an internal combustion engine to provide emission reductions, comprising:

a first, second and third zone, said first zone comprising a) a catalyst mixture PM-Rh where PM is a catalyst mixture selected from the group consisting of Pt, Pd and combinations thereof, and b) a metal oxide selected from the group consisting of cerium, zirconium and combinations thereof; said second zone comprising a) a catalyst mixture Pm-Rh, where PM is a catalyst material selected from the group consisting of Pt, Pd and combination thereof; and b) a metal selected from the group consisting of oxides of aluminum, alkali metals, alkaline earth metals and combinations thereof, wherein said second zone is devoid of cerium; and said third zone comprising a) a hydrogen sulfide suppressant, b) a catalyst mixture PM-Rh where PM is a catalyst material selected from the group consisting of Pt, Pd and combinations thereof, and c) a metal oxide selected from the group consisting of cerium, zirconium and combinations thereof.